Industrial Hydraulics | Electric Drives and Controls | Linear Motion and Assembly Technologies | Pneumatics | Service Automation | Mobile Hydraulics

Rexroth
Bosch Group

Systems & Engineering
Materials Handling
Luffing cranes

Engineering hints for modernization and new construction

INDEX

INTRODUCTION

Spectacular, new developments in the field of container handling hide the fact that the classic level luffing crane is still the backbone in the field of materials handling for sea and river ports.
These all-rounders can be found everywhere. Apart from materials handling on the waterside, innumerable machines with hooks, grabs or load magnet operate on scrap yards or within industrial facilities.

This paper refers not only to new machines, but mainly to somewhat outdated level luffing cranes. According to our experience, these machines are in most cases well maintained and looked after and their steel structures are still in very good condition. However, in many cases they were equipped some decades ago with technology that was available at that time, but with regard to performance, sensitivity of movements and maintenance requirements, they can no longer come up to operators' expectations today.

Modern hydrostatic drives with cylinders and planetary gears offer more favorable efficiencies than spindles or spur gears. An increase in performance is therefore in most cases feasible without increased power requirement, provided that the crane mechanics permit this.

From everyday life, the personnel are used to a high operating comfort. The technology of the old machines, which was absolutely acceptable in the past, allows sensitive movements to a restricted extent only.
Modern systems are usually electronically controlled. Adjustable characteristics allow an operating comfort tailored to the requirements at hand. The brakes are applied and released automatically; it is no longer necessary to operate levers or pedals.

The classic electromechanical drive with open toothing needs comprehensive maintenance. In many cases, the manufacturers of the old cranes are no longer existent. Here, the maintenance personnel must have talent for organization and improvisation when it comes to the procurement of spare parts.
Hydrostatic systems operate largely maintenance-free. All movable parts are positively and permanently lubricated; servicing is restricted mainly to filter changes and oil care at fixed intervals. Due to the drastically reduced maintenance effort, modernization pays off after only a few years.

The specialists of BOSCH REXROTH, teamed up as Corporate Center of Competence in the specialist department "Materials Handling", have cooperated for many years with colleagues from all over the world not only on the engineering of new equipment, but also on the modernization of drives.
These activities follow the trend of preserving the value of machines instead of scrapping them prematurely and procuring new ones. A desirable by-effect is that performance, functions and maintenance friendliness are improved.

A drive can be modernized in cooperation with the crane manufacturer, but also together with the maintenance personnel of the operator.

Fig. 01: Harbour Vostochny, Russia – handling of log

CONSIDERATIONS BEFORE THE MODERNIZATION

It has proven successful to involve the responsible machinist and the maintenance personnel in all activities. Nobody else is so familiar with the crane. Their wishes can often be realized without any extra expenses.

Please note for your schedule that the engineering and manufacture of components takes about 6 months. In order that the crane can remain in operation with the old equipment as long as possible, the installation of the power pack, pipework and the cabling of electrical systems can be carried out during stoppages before. The machine will then have to be shut down only for the replacement and connection of drives and commissioning.

The more functions are supplied by the hydraulic power pack, the less expensive becomes the modernization. For operation, this offers the advantage that maintenance work is restricted to only one place in the crane. Apart from converting the boom adjustment, it is particularly favorable to modernize the slewing drive. Before a planned conversion is carried out, you should therefore verify, whether any existing controls for locks, tensioning facilities or brakes can be combined with the luffing power pack.

Operators often plan to convert several functions, but wish to realize this in two stages for cost or logistic reasons. If this is known, it makes sense to provide the installation space and connections for the other functions right from the start. This helps to avoid costly and complicated changes at a later date.

Due to wear and tear, the old drives operate with unfavorable efficiency. During the conversion, it is therefore possible to realize higher velocities within certain limits without having to install greater power. Please give also your crane operator permission to speak. He knows, whether the velocities currently available harmonize in the operational interaction.

Also the use of removed parts should be considered. Level luffing cranes rarely operate as stand-alone units. Should you plan to modernize an entire series of cranes, we recommend that you leave one or two machines in the old technology for the time being. They could be employed in the modernization of the other machines and the removed drives could be used as spare parts for a certain period of time.

For the preparation of the offer, we require some details. Assistance for this is provided in the form of a questionnaire with explanations, which is enclosed at the end of this brochure.

Fig. 02: Level luffing crane with double-rod cylinder in Koper / Slovenia

LUFFING CYLINDER

An application which is ideal for the use of a hydrostatic cylinder drive is the boom luffing drive of level luffing cranes.

Electromechanical spindle type boom adjustment

Even newer cranes are still provided with an electromechanical adjustment feature consisting of a spindle, spindle nut, gears, electric motor and brake.

This results in some disadvantages for the operator:

- Even if the spindle is protected, it is nevertheless susceptible to corrosion due to downtimes lasting for days and the salty atmosphere. Lubrication is required.

- The spindle nut is subjected to significant wear. Depending on the operating conditions, the nut has to be replaced approximately every 2 years.

- External forces generated, for example, by snagging of the load in the ship must be absorbed by the spindle. Merely the elasticity of the lifting ropes has a damping effect. However, in the case of direct collision of the crane mechanics, the spindle must absorb the full shock load. This is the case when the boom hits an obstacle and the spindle is subjected to buckling loads.

- The sensitivity of the control, especially with older cranes without controlled spindle drive motors, leaves much to be desired. For this reason, the luffing speeds were limited by the manufacturers to a greater extent than the operation would actually require. These limitations affect the interaction of the crane movements in loading processes.

- In individual cases, the efficiency of the electromechanical drive is only 50%

- Especially with old machines, the spare parts supply may be critical, since some manufacturers are no longer existent. Spindle drives for such applications are not off-the-shelf products. The designs, which are mostly tailored to the individual applications, result in expensive spare parts.

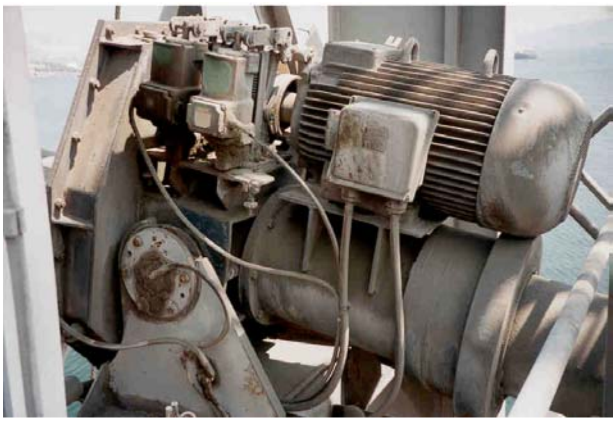


Fig. 03/04: Drive unit and cardanic mounting of the electromechanical spindle adjustment

LUFFING CYLINDER

Hydraulic boom adjustment
These problems are solved when a hydraulic cylinder is selected.

- The cylinder is maintenance-free. Maintenance work is restricted to oil servicing and the change of filter elements in the power pack. If the prescribed intervals are adhered to, a long service life can be expected. Except for the filter elements mentioned before, no wear parts are installed.

- The overload protection against compressive and tensile forces is reliable and also effective when the machine is switched off.

- The sensitivity of the control is impressing. Any speed characteristic required can be realized. Acceleration and deceleration ramps can be adjusted during commissioning.

- Within the framework of the modernization, a higher luffing speed can easily be realized within certain limits, provided that the mechanics of the crane allows this. In terms of power consumption, this is not critical, because the hydrostatic drive features an efficiency of at least 75 %. The difference in relation to the previous electromechanical drive compensates for the higher requirement when the speed is increased.

- No other known machinery element offers a power density comparable with that of a hydraulic cylinder. With regard to the dimensions, the cylinder must be adapted to the installation situation in both cases, for conversions and new designs. However, internal parts such as seals, guides or pistons are taken from the standard product range.
  Dimensioning of a spindle drive is not only determined by stresses, but also by notch effects acting on the threaded rod. In contrast to this, the cylinder piston rod can be dimensioned with a smaller diameter. Thanks to the efficiency and power density of this technology, the hydraulic cylinder is significantly smaller and also lighter. A hydraulic cylinder always fits in the installation space of a spindle drive!

- Unlike the spindle arrangement, the drive is not mounted onto the outer tube. The oil supply can be arranged at an almost optional distance in the crane's protective housing or on its roof to provide ease of maintenance and good accessibility. Only a few lines are required to connect the power pack to the cylinder.

- A safety block flanged directly onto the cylinder locks the cylinder automatically in any position as soon as it has come to a standstill. It also includes pressure relief valves for protection against external forces. The block is described in more detail in the following text.

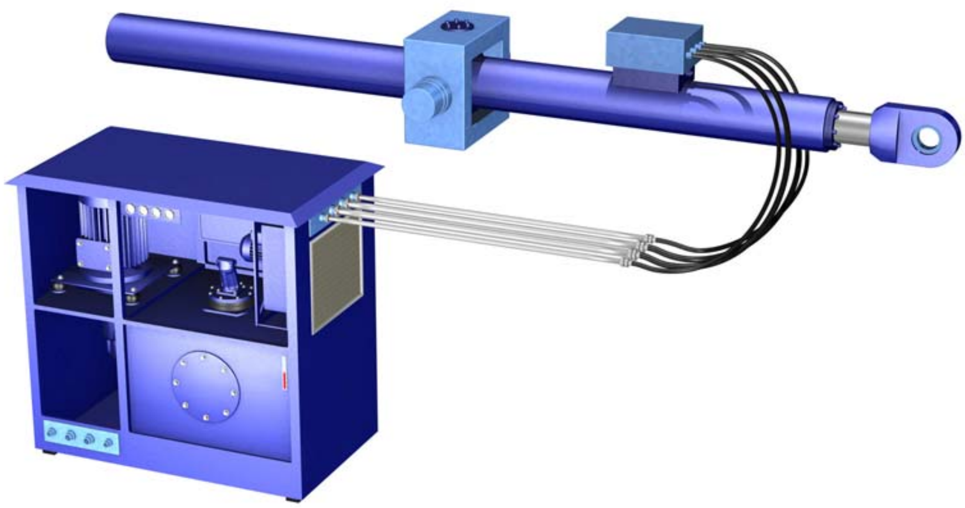


Fig. 05: The power pack can be installed at any place to provide ease of maintenance

LUFFING CYLINDER

Luffing cylinder designs

A single-rod or a double-rod cylinder can be selected for the boom adjustment. Both design types are usually supported in the crane using a cardanic trunnion mounting element. The frame for the cardanic support which is welded from steel sheet is included in the scope of supply for the cylinder. The eye that is provided with a spherical bearing at the piston rod is to be mounted in the boom. This concept rules out alignment errors between the trunnion and the piston rod eye.

Fig. 06/07: The cardanic support and the mounting element of the eye are custom-made.

As the word indicates, the double-rod cylinder is provided with 2 piston rods, allows a simpler control, but is more expensive. In individual cases, it may be disturbing that the “inactive” piston rod protrudes at the rear. When a new crane is designed, care must be taken that the piston rod does not extend into the operating range of the movable counterweight. In the case of very long cylinder strokes, bending of the piston rod must be taken into account. It may have to be supported via an auxiliary winch. Irrespective of the position taken by the cylinder when it is put out of service, one of the two rods is always extended and therefore susceptible to corrosion.

The provision of a double-rod cylinder is generally possible, but we recommend the selection of a single-rod cylinder. This variant requires no free space at the rear and, since the piston rod is retracted in the parking position and consequently protected against corrosion.

The lower cost of the cylinder is set off by the higher price for the power pack so that in the end the prices for systems with single or double-rod cylinders are identical.

BOSCH REXROTH supplies, of course, both designs, but in the following descriptions we refer to a system with single-rod cylinder.

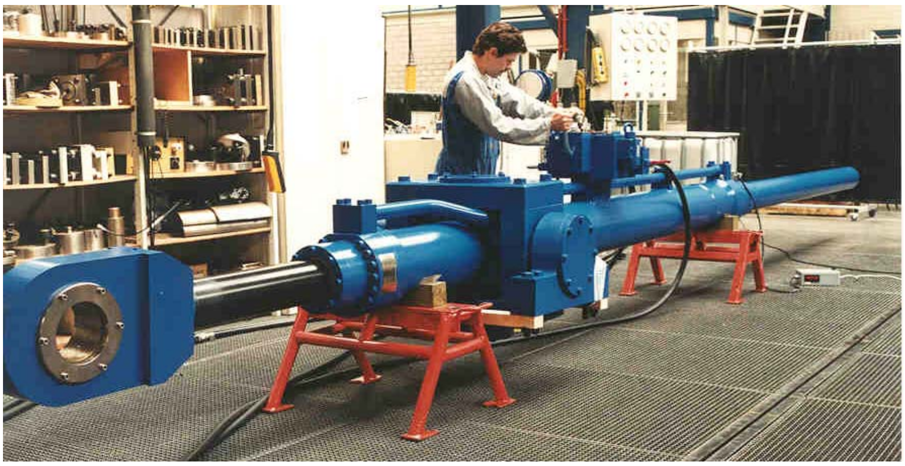


Fig. 08: Final assembly of a luffing cylinder

LUFFING CYLINDER

Control of the luffing cylinder

The cylinder is controlled according to the principle of the semi-closed circuit. With this system, the load cycles between pulling and pushing forces that usually occur on slewing cranes are handled with low losses and without the need for brake valves or throttle valves.

In the case of closed circuits, the main pump does not aspire oil from the oil tank, but the two pump lines are directly connected to the cylinder chambers. When the pump delivers oil into one chamber, the oil displaced is again fed to the pump on the opposite side. The process takes places alternately; the oil always circulates between the two cylinder chambers, with the direction of movement being determined exclusively by the pump in dependence upon the control. The pump is an axial piston pump that can be steplessly adjusted from the neutral central position to both directions up to the maximum flow. In the neutral central position, the flow is zero, but the pump maintains the current pressure and thus holds the load.

Depending on pulling or pushing force, the working pressure is generated on one of the two cylinder sides ("high-pressure side"). This high pressure is supported via the line, pump and pump drive motor on the electric mains. The mains therefore assumes the function of the dynamic service brake. As already mentioned, load cycles caused by changes in the direction of load are irrelevant, even when the cylinder is moving. The change of the high-pressure side is not perceptible for the crane operator and has no influence on the speed or characteristics.

When a single-rod cylinder is used, it can easily be understood that the larger piston chamber requires a larger flow than the annulus chamber. The main pump dimensioned for the annulus chamber is not sufficient for this. For this reason, an axial piston motor is interconnected in the line to the piston chamber and is exclusively used for driving a further axial piston unit – the auxiliary unit. We call this axial piston "unit" with a neutral term, because it operates as both, pump and motor. This combination is termed "flow divider".

The flow divider is flexibly mounted on the oil tank cover. The hydraulic drive motor is located outside, whereas the auxiliary unit is installed in the tank. Since the auxiliary unit aspires oil from the tank or feeds oil back to it, we speak of a "semi-closed circuit".

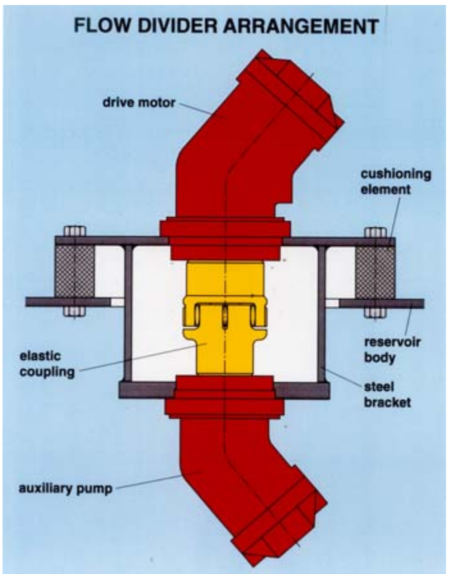


Fig. 09/10: Structure of a flow divider combination

LUFFING CYLINDER

When the cylinder extends, the hydraulic motor powers the auxiliary unit so that it acts as a pump, aspires oil from the tank and delivers it together with the main pump to the piston chamber of the cylinder.

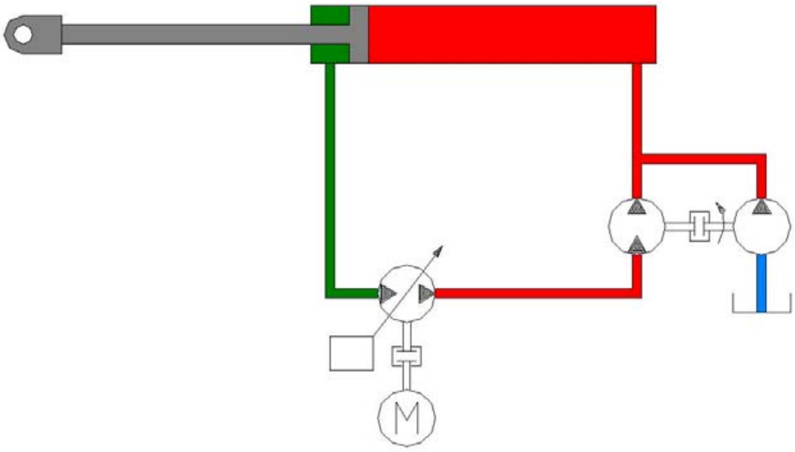


Fig. 11: Extension of the single-rod cylinder

In the opposite direction, when the cylinder retracts, the main pump delivers oil into the annulus chamber. The oil displaced from the piston chamber is divided in the flow divider according to the geometric swept volumes, with one part flowing via the motor back to the main pump, the other part via the supplementary unit into the tank. The auxiliary unit consequently acts as a motor when the cylinder retracts.

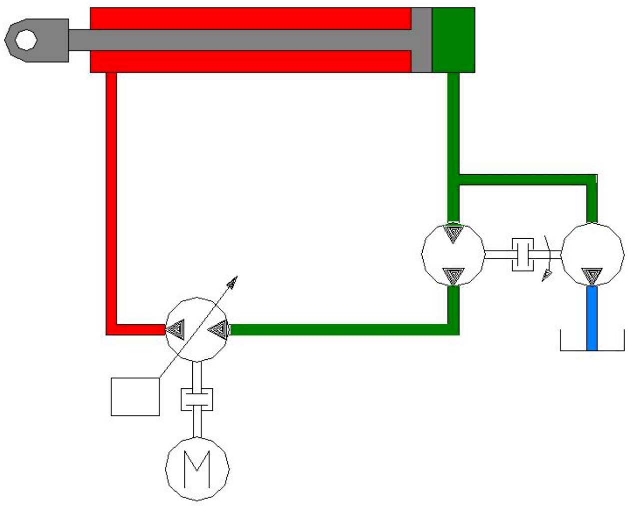


Fig. 12: Retraction of the single-rod cylinder

To prevent vibrations, the cylinder does not travel to the end positions during operation. Shortly before the end of stroke is reached in both directions, the velocity is reduced until the cylinder comes to a standstill about 50 mm before the mechanical limit stop. Usually, the signal of the outreach indicator, for example a rotary angle encoder at the base point of the boom, is used to determine the required velocity profile.

LUFFING CYLINDER

The safety block
The safety block with valves for locking and protecting the cylinder is directly mounted to the cylinder barrel. Located at an easily accessible place, it is rigidly piped with the cylinder chambers and connected via hoses to the hydraulic system on the power pack side. The cylinder and block form a maintenance-free, ready-to-install unit.

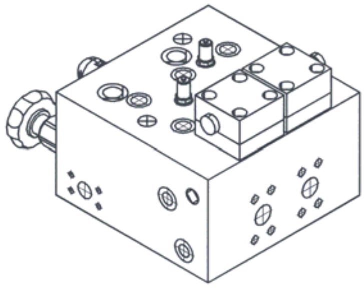


Fig. 13/14: The cylinder is safely locked in any position

Theoretically, additional holding equipment is not required for the cylinder; it can be supported via the line, the main pump and the pump drive motor on the electric mains. However, this is only possible when the pump drive motor is switched on. Moreover, the pump has a small internal leakage that is required for design reasons to ensure lubrication. Even when the motor is switched on, the stopped load would imperceptibly, but continuously, “creep away” due to this leakage.

Holding equipment is therefore required in the stopped status. This function is assumed by pilot operated check valves, which change automatically over to the safe closed position, when the pump is in the neutral position or, in other words, when the cylinder movement is stopped. Further automatic safety links, for example in the event of a power failure or cable break, also cause the check valves to close so that the boom is safely locked in any position and under any load. The check valves are released automatically shortly before the main pump starts to swivel.

An absolutely realistic event is snagging of the load or the grab in the ship. If this remains unnoticed by the crane operator, the boom is pulled down by the active hoisting drive. Of course, the load moment limiter switches the lifting movement off as quickly as possible, but this shutdown process may be too slow, especially on cranes with relatively inert hoisting motors. The ropes, the boom and the grab itself are subjected to unnecessarily large loads. In extreme cases, the crane can even topple over.
A pressure relief valve on the pulling side of the cylinder acts as deliberate weak link and opens under this extreme load. The boom therefore can give way. The setting of this valve defines the max. possible pulling load of the cylinder. The mechanics must be dimensioned for this value. However, during normal operation, the pressure relief valve, which is set about 20 % higher than the maximum operating pressure, does not respond.

In the opposite direction, it may happen that the boom head hits an obstacle, for example a second crane or upper works of the ship. Here, the cylinder is subjected to buckling loads. A second pressure relief valve on the piston rod, which is set to a safe value, protects the mechanics and the cylinder from excessive buckling loads.

Together with the check valves mentioned before, both pressure relief valves, which are firmly set, TÜV-tested and sealed, are integrated in the safety block, which, for safety reasons, is flanged directly onto the cylinder.

Should a valve have to be replaced in the course of a repair, it is possible to isolate the cylinder by closing two hand-wheel valves. Thus, it is possible to work on the valve without any risk, while the boom can be in any position; the cylinder needs not to be moved to either end position.

LUFFING CYLINDER

Boosting, cooling, filtration

While the cylinder is leak-free – only a small amount of entrained oil wets the piston rod – a small leakage flows within the pump from the high-pressure side to the low-pressure side and into the housing, which is drained via the leakoil port to the tank. This is a desired process; the low flow loss ensures the required self-lubrication and a reliable dissipation of heat.

In order that the circuit does not drain in the course of time, it must be topped up. To this end, a service pump flanged to the main pump continuously feeds in oil via the relevant low-pressure side. This circuit is limited to 20 – 25 bar.

The service pump delivers a constant flow that continuously circulates the tank volume through a filter and oil cooler. This is more favorable than filtration of the working lines, because this would only be effective as long as the cylinder is moving, whereas the service circuit is permanently available with the full flow.

Controlling of the pump

The electronic control of the main pump determines the direction of movement and the velocity of the cylinder. For this, BOSCH REXROTH can offer comfortable hand lever devices for installation in the arm rest of the seat or the side of the dashboard. 2- or 3- axis control devices with shifting gate for diagonal operation is available as a standard. Rocker switches for the operation of the grab or dead man's buttons complete the device.
The electronic devices control the electronics of a proportional solenoid, which in turn adjusts the pump displacement. The electronics translate the control signals of the encoder into the required valve solenoid current.

The electronics can be integrated in the control device, in the proportional valve or in an amplifier card. It is included in BOSCH REXROTH's scope of supply and forms the interface with the electrical system of the crane.

Fig. 15: New luffing cranes in Cuxhaven / Germany

SLEWING DRIVE

If the boom adjustment is to be changed over to hydrostatics, you should consider including the slewing drive. The extra expenditure for impressing advantages is minimal. Should you wish to carry out a comprehensive conversion, but for cost reasons not simultaneously, BOSCH REXROTH will take the required measures into account for the power pack. The slewing drive can then be retrofitted without any difficulties.

The slewing drive is undoubtedly the most sensitive drive of a crane. Even a minimum turn of the superstructure results, depending on the outreach, in traveling of the load with the corresponding transmission ratio. The demands placed on a slewing drive must be assessed according to the application of the crane.

Fig. 16: .....the modernization of the electro- mechanical slewing drive should be considered

Slewing drives for bulk or scrap handling cranes

The decisive factors for level luffing cranes for bulk material are acceleration, fast slewing and deceleration. Another important aspect is the load generated by external forces. For example, in order to achieve the optimum degree of filling, a grab or load magnet is thrown into the goods to be handled so that it digs in deeply under its own weight. The final location cannot be influenced, the boom needs not to be positioned exactly above the grab. When the crane operator now actuates the hoisting drive, the superstructure pulls itself automatically to a vertical position above the load. In this situation, it must be possible that the slewing drive can freely move under external loads in order to prevent damage to the rope or even the boom supports due to undesirable oblique pulling. On the other hand, for emptying the grab above the hopper, precise positioning is a must.

The performance and duty cycle required from slewing drives of cranes for bulk material are significantly more demanding than those of general cargo cranes. It can easily be understood that the slewing drives must be solidly dimensioned and highly classified for such a dynamic operation.

Slewing drives for general cargo cranes

With general cargo cranes, dynamic loads are less critical. On the other hand, soft acceleration, precise slewing and accurate stopping within the order of centimeters are indispensable. Stress caused by external forces occurs only in the event of a fault, e.g. snagging of the load.

Characteristics of the hydrostatic drive

The demands placed on positioning accuracy clearly show that slewing drives with a high resolution are a must. The best solution are large transmission ratios and well controllable, high-speed drive motors.

The proven hydrostatic drive can meet these requirements. BOSCH REXROTH designs the control according to the tried-and-tested principle of the closed circuit. The drive starts up jerk-free from standstill independently of the load and accelerates proportionally to the lever movement and linearly up to the highest speed.

Braking is accomplished exclusively by means of the hydraulic system, with the load being supported via the hydraulic motor, the lines, the pump and the pump drive motor on the electric mains

SLEWING DRIVE

The core of the system is the main pump that can be swiveled over zero in both directions. It swivels out in dependence upon the control command and determines the direction of rotation and, also in accordance with the lever deflection, the amount of the revving speed. When the movement is reversed, the slew drive stops and then accelerates in the opposite direction. The holding brake opens automatically shortly before the slewing movement starts and is only re-applied after standstill has been reached; the brake therefore operates virtually wear-free.

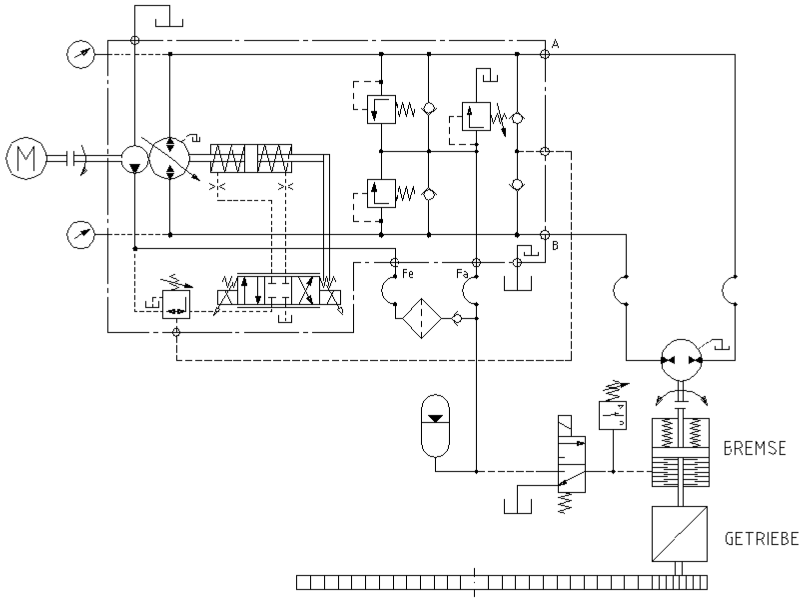


Fig. 17: Circuit diagram of the hydraulic slewing drive

In contrast to this, electrical drives are difficult to control, especially in the lower speed range. The closed-loop control requires a minimum speed for the acquisition of the actual value. At the beginning, the characteristic curve of the control lever is flat before it rises proportionally to the actual slewing movement. In addition, without external venting, electric motors cannot perform positioning movements at creep speed for an unlimited period of time, since the cooling capacity of the ventilator on the motor shaft is not sufficient at low revving speeds.

This problem does not arise with hydraulic motors; it is possible to perform positioning movements at low speed for an unlimited time and independently of the load. As already mentioned, the hydraulic drive accelerates from standstill smoothly with a linear characteristic curve. Experienced crane operates comment that the hydrostatic slewing drive can be operated “more directly”. The slewing drive circuit on cranes is generally engineered separately in order that it can be operated together with any other of the crane main functions.

Parallel operation of several slewing drives

The constructive height and toothing of the slewing ring between the superstructure and the gantry limit the torque that can be transmitted. It must also not be forgotten that in particular cranes for bulk material always slew in the same segment and therefore always the same toothing areas of the slewing ring are subjected to stress and wear. A solution to this problem is an arrangement of several small instead of one large slewing drive. For new designs, a smaller tooth module can be selected, because the load is distributed to several drives. This results in a flatter and consequently less expensive slewing ring. In addition, symmetric loading has a positive effect on the service life of the slewing ring.

A fundamental advantage of hydrostatics is the operation of several slewing drives without any complicated control arrangements; the hydraulic motors are simply connected in parallel via the lines. For physical reasons, the working pressure that is generated during slewing and thus the output torque of each motor is equally high. The absolutely symmetrical distribution of load causes a slight charging of all slewing drive pinions, thus eliminating even the slightest tooth profile backlash. With electrical drives a complicated control would have to be implemented for this.

SLEWING DRIVE

Enabling of the slewing drive

If, with cranes for bulk material, the grab or load magnet is thrown into the bulk goods or scrap, the boom is in most cases not positioned vertically above the load. When the crane operator now activates the slewing drive, the slewing superstructure pulls itself automatically above the grab or magnet. If the slewing drive is now blocked, the rope is pulled obliquely, which results in damage to the rope guides and possibly to the boom supports. In addition, the grab swings more violently when it is lifted off the floor.
In order that the superstructure can pull itself over the load, the slewing drive must move freely. The crane operator usually presses a foot switch or a button on the control lever. Then, a solenoid valve briefly closes the hydraulic working lines and opens the brakes. The force-locked drive train is therefore interrupted and the slewing drive can be freely moved. Just mechanical friction of the gearbox and toothing have to be overcome.

Overload protection

Hydraulic drives and also the mechanics are simply and reliably protected from overload. Here, we must distinguish between active and passive loading.

Active overload is caused by excessive resistance, for example due to extreme wind, snagging of the grab in the ship or because the crane operator unintentionally hits an obstacle.
This automatically results in a limitation of power of the hydraulic system. For this, the main pump is fitted with a “pressure cut-off feature”. If the working pressure exceeds a value set on this feature, the pump swivels back to the neutral position. The pressure is maintained, but the flow becomes zero and the movement is stopped. The pressure cut-off feature serves for protecting the hydraulic system and the drive motor from overloading. With this process, there is no generation of heat as is the case when pressure relief valves discharge. The blocking may be present over an unlimited period of time.

When external forces act on the slewing drive, for example, because the ship is moving and causes the boom with the load or the grab to turn away, we speak of passive overload. When the drive has been stopped by the pressure cut-off feature, the working pressure continues to rise in an uncontrolled manner. Reliable and continuously effective pressure relief valves that are set higher than the pressure cut-off feature protect the slewing drive from these extreme loads. The valves open at a defined pressure and relief the excessive pressure into the opposite working line. Of course, this process generates heat and should therefore be completed within a short time. This passive protection represents the highest possible pressure in the hydraulic system. All the components are rated for this, but also the mechanics must be dimensioned taking into account these peak loads.
However, it must be clearly said that all hydraulic limiting features are only effective when the brake is released, i.e. as long as the crane operator actuates the lever. When the brake is applied, the pinion, gears and brake must withstand the loads!

Fig. 18: Hydrostatic slewing drive with gearbox, brake and axial piston motor

SLEWING DRIVE

Partial modernization
When the existing gearbox is still intact or when sufficient spare parts are available, it is also possible to merely replace the electric motor by a hydraulic motor. We do not recommend this solution, if the existing electrical drive is frequency-controlled. The conversion to a hydraulic drive would then not result in worthwhile advantages. However, if the drive – in particular on older cranes – is equipped with conventional multiple contact switches, we recommend that the motor be replaced. Dynamic brakes, if any, are then no longer required, because braking is effected exclusively by the hydraulic system. They can be removed or remain permanently open. However, a holding brake is still necessary. Flanged between the motor and the mounting adapter, a multi-disk holding brake is a proven and cost-effective solution. The existing holding brake can, of course, be used, but the encapsulated multi-disk brake is largely maintenance-free.
No matter, which brake you prefer: A slewing drive holding brake should be supplied by the hydraulic system. Any brake release devices, which, in principle, are also small hydraulic systems, are no longer required; servicing is restricted to the hydraulic system. The effort is limited to a minimum; merely a solenoid valve and the line from the power pack must be installed.

Complete replacement or slewing drives for new machines
If the gearbox is worn out so that you have to buy spare parts, we recommend the complete replacement of the drive. A combination of planetary gears, spring-applied multi-disk holding brake, hydraulic motor and adapter substitute the existing drive. The pinion can be supplied on request. In this case, the output shaft and pinion are made of single-piece, forged and case-hardened steel.
We prefer this concept, since with this, the smallest number of teeth can be realized on the pinion. This reduces the torques to be handled and makes the gearbox less expensive.

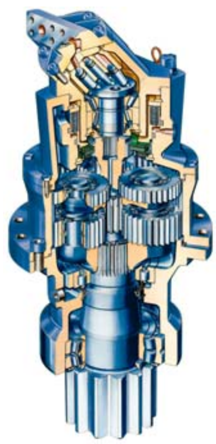
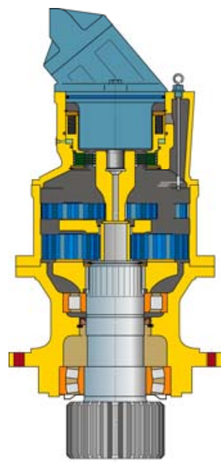




Fig. 19/20/21: Compact and maintenance-friendly: Planetary slewing drives with holding brake and hydraulic motor

Oil supply
In most of the cases, an existing power pack can be supplemented by the slewing drive pump and the associated control without any problems. Due to the selected principle of the closed circuit, the oil tank needs not to be enlarged. It must be verified, in particular with level luffing cranes for bulk material, whether the output of the pump drive motor is sufficient. The reason for this is that the slewing drive is usually operated simultaneously with other functions. With a new power pack, these requirements are naturally taken into account.

BRAKES

We recommend that a hydraulic power pack provided within the framework of modernization be utilized to the optimum extent. For additional small consumers such as lifting gear brakes or slewing drive brakes, only a few components have to be added.

The brake release devices commonly used on electrical drives are just small, independent hydraulic systems which, of course, also have to be serviced. They can be replaced by simple actuating cylinders. In practice, this means that the existing cylinder will remain at the brake and the control parts fitted will be removed.
A power pack that may be existent for controlling the brakes is no longer required.

The supply of all the existing hydraulic consumers should be integrated in a new power pack. Thus, maintenance work for the hydraulic system is concentrated to one place in the crane.

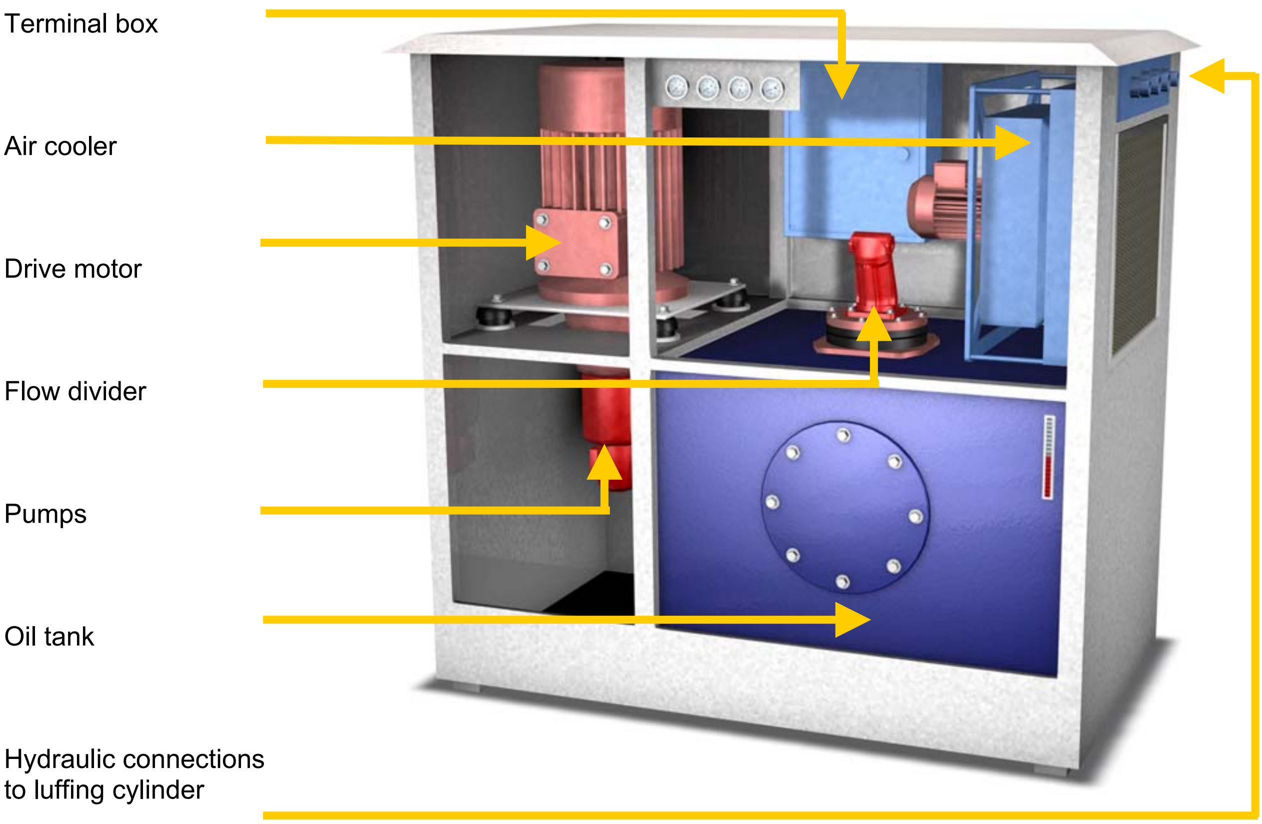
*Fig. 22:
Level luffing crane with hydraulic operation of various brakes*

POWER PACK

Pumps, pump drive motors, oil tank and control are integrated in this power pack. Provided that the crane is not a special crane with extraordinary requirements, BOSCH REXROTH can offer standardized product series for the most essential components.
The power pack comes ready for installation, tested, flushed and painted.

The power pack will be connected to the piping system using short hoses. A terminal box, to which all electrohydraulic components of the power pack are wired, forms the interface with the electrical system.

Fig. 23: Structure of the hydraulic power pack



POWER PACK

Drive motor and pumps
In order to keep the required floor space as small as possible, the pump/motor group is installed vertically. It is mounted vibration-free on a frame. An advantage of this is that the suspended arrangement eliminates bending moments acting on the pump combination and reduces the starting shock load.

Oil tank
The oil tank is generously dimensioned for handling operation. Due to the principle of the semi-closed circuit, the volume can be selected efficiently small. The air buffer above the oil level amounts to about 15 – 20% of the total capacity. Due to the differential volume of the cylinder, the oil level fluctuates; the air volume breathes via a fine breather filter. Generally, all add-on components are to be mounted on inspection covers.
The suction openings of the pumps must generally be immersed in oil. In order to prevent loss of oil when repairs are to be carried out, shut-off valves with position monitoring switches are installed in the suction lines.

Oil level
A float switch on top signals, if the oil level has fallen to an impermissible level due to repairs or leakage. A sight-glass allows visual oil level checks. In accordance with water protection regulations, an oil drip tray under the power pack is dimensioned so that it can collect the entire tank volume.

Oil heater and oil cooler
In order that the pumps can start up during the cold season, a defined minimum oil temperature is required to which the oil volume must be warmed up. We do not like to use immersion heaters, since the oil does not move in the tank when the system is switched off, which can cause local overheating (cracking) of the oil on the heaters, whereas in more distant zones of the tank, the oil remains cold. This results in premature aging of oil.

Depending on the requirements, BOSCH REXROTH favors one or more oil heating motors that are fixed inside the tank with permanent magnets. These are electric motors with external rotor and aluminum rotor propeller, which keeps the oil permanently in motion, even when the system is switched off, and thus results in uniform heating of the entire oil. The total power taken from the mains is converted into heat. The motor is switched on and off automatically with the help of an integrated temperature sensor, which activates the heating system at temperatures below 10 °C and switches it off when a temperature of about 20 °C has been reached. For the electrical supply, the heating motor is wired via a terminal box on the tank cover to the terminal box of the power pack.

As soon as the pumps start up, the optimum operating temperature of 50 – 60 °C can quickly be reached. Although slightly higher temperatures are not at all a problem – just aging of the oil is accelerated – this optimum temperature should be adhered to.

A common misunderstanding is that a large-sized oil tank significantly contributes to cooling. This is true for systems with intermittent operation, because longer cooling phases occur. However, with systems designed for continuous operation, a large volume just means that the dwell temperature is reached later. The cooling performance through dissipation via the tank surface is small, only about 15 W per m^2 of the wetted surface is effective. Nevertheless, a large oil volume has a positive effect on aging of the medium.
Oil cooling is therefore indispensable on level luffing cranes.

This can be accomplished easily by means of oil/air coolers with an electrically powered ventilator. The ventilator is automatically switched on at 60 °C and off when the temperature falls to 50 °C. In addition, a bypass valve is installed between the cooler inlet and cooler outlet. Switched via a wax thermoelement, it lets the oil bypass the cooler up to a temperature of about 55 °C, then closes, thus forcing the hot oil to flow through the cooler.
The temperature is monitored via an electronic resistance thermometer, which sends an analog signal to the PLC, thus controlling the heating and cooling action described above. An additional, separate thermometer allows visual checking of the oil temperature.

POWER PACK

Power pack next to the luffing cylinder
The drive power pack can be arranged according to your requirements. The installation near the luffing cylinder helps to cut installation costs of the hydraulic lines. However, in this case, weather protection is required. This arrangement is recommended, if only the boom adjustment is to be modernized. If further functions were to be connected, the savings in the pipework would be set off, since longer lines would have to be installed, for example, to the slewing drive or the brakes.

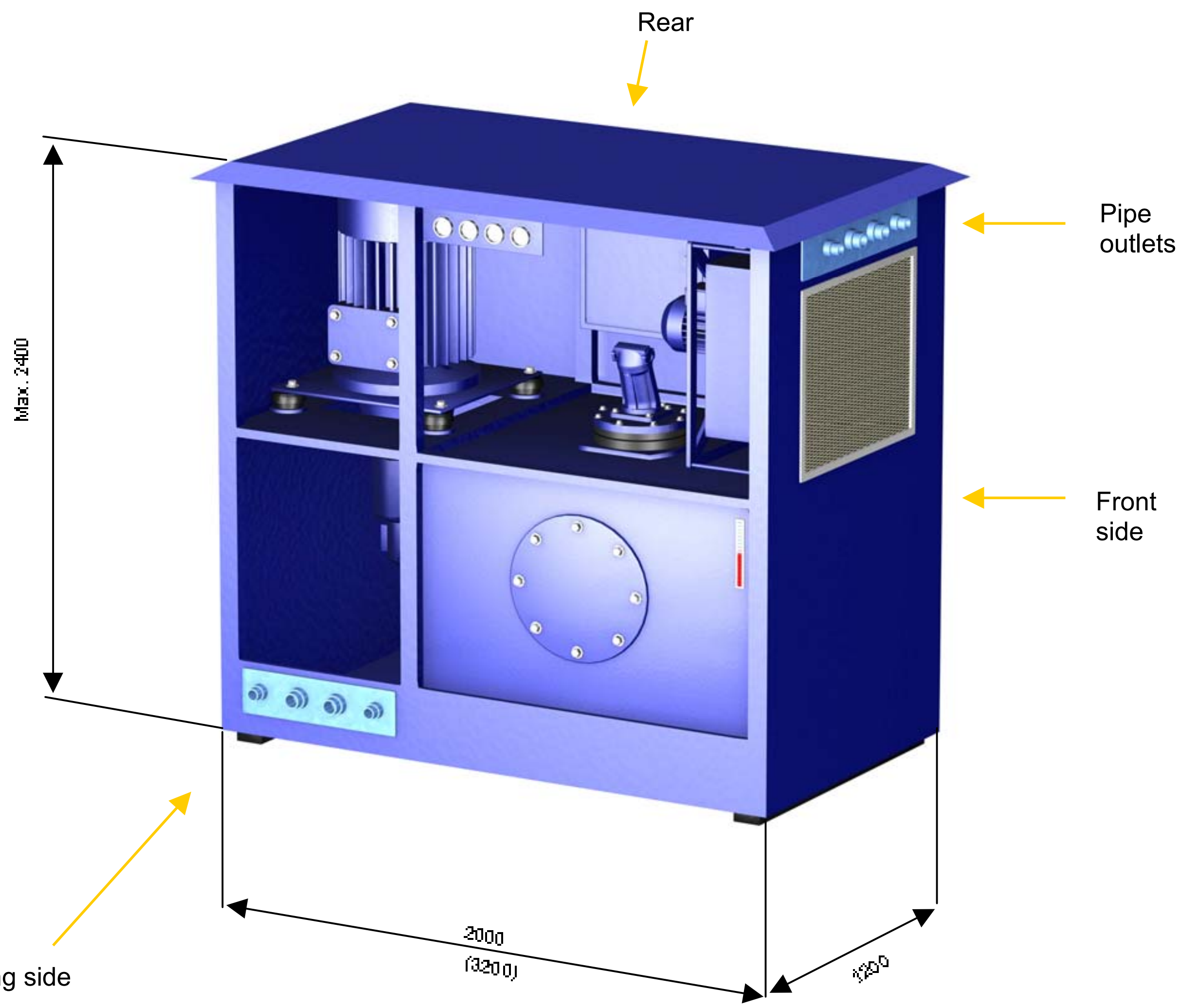
Fig. 24/25: The arrangement on the roof saves pipework, if only the luffing cylinder has to be supplied

Power pack in crane's protective housing
Due to the more favorable piping arrangement, the location in the crane’s protective housing should be opted for, if the power pack is to supply not only the luffing cylinder, but also the brakes or the slewing drive. In this case, protective covers are not necessary.
The oil/air cooler is relocated from the power pack into a cut-out in the protective housing wall, from where it can, apart from performing its actual function, vent the entire protective housing. Moreover, the location of the power pack in the protective housing allows comfortable servicing.

Fig. 26: Weather-protected and maintenance-friendly: Arrangement in the protective housing The photograph shows the oil cooler above the power pack in the wall of the protective housing

POWER PACK

Fig. 27: Dimensions of the power pack



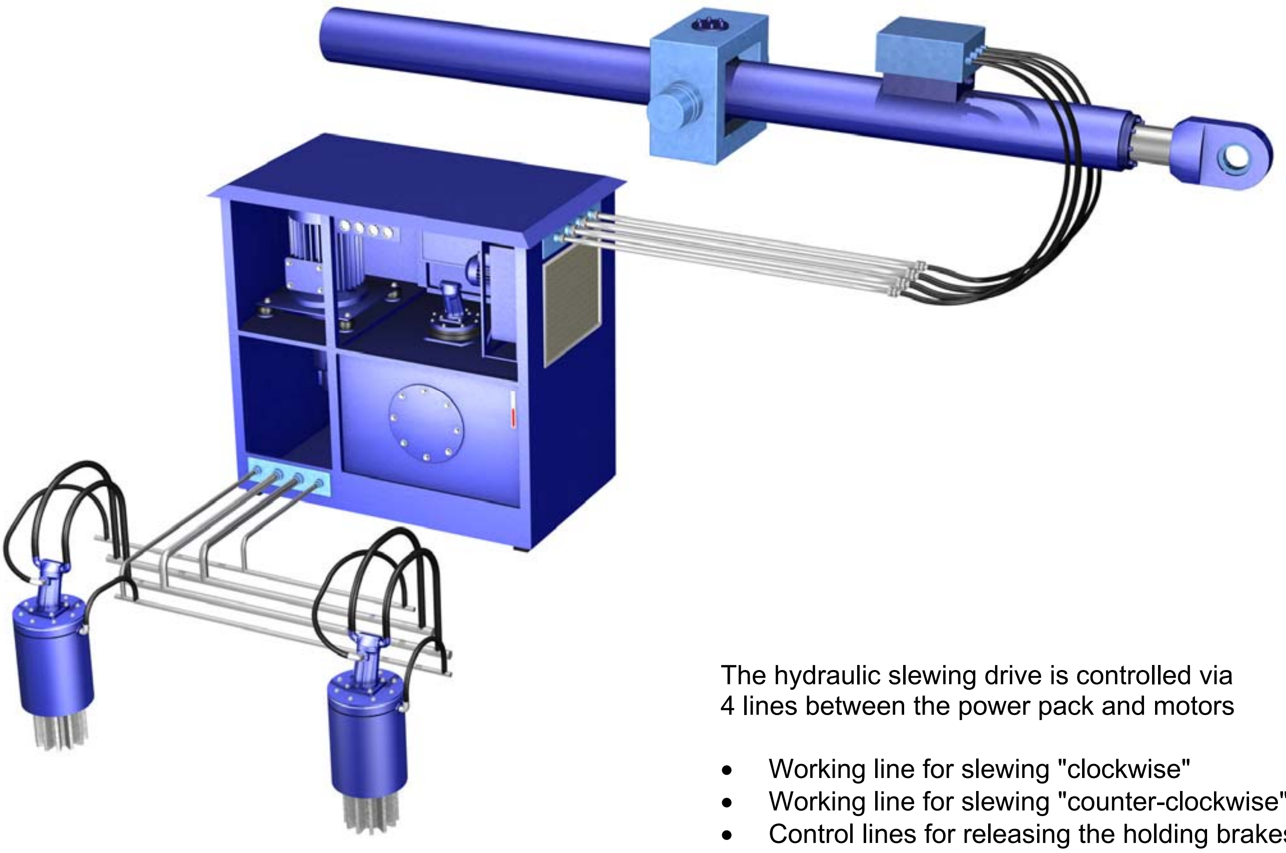
When intended for outdoor installation, the operating side is provided with doors.

PIPEWORK

Fig. 28: Piping of cylinder, power pack, motors

The hydraulic luffing gear is controlled via 4 lines between the cylinder and the power pack:

- Working line for extending the cylinder
- Working line for retracting the cylinder
- Control line for releasing the check valves
- Tank line



The hydraulic slewing drive is controlled via 4 lines between the power pack and motors

- Working line for slewing "clockwise"
- Working line for slewing "counter-clockwise"
- Control lines for releasing the holding brakes
- Leakage line

PIPEWORK

If the power pack is located very close to the cylinder, simple, 3-4 m long hose lines are sufficient. For longer distances, pipes are to be used; at their ends, the cylinder and power pack are to be connected using short hoses. We recommend that the location of the power pack be determined taking this aspect into account.

For technical reasons, but also in view of cutting costs, the pipework should be kept as short and straight as possible. Pipes should *not* be connected directly to the drives or the power pack; short hoses at transitions compensate for relative movements and alignment errors. They also prevent the transmission of vibrations from the drives and the power pack to the lines.

Each fitting should be provided with a seal ring; purely metal seal connections must be avoided in any case! From defined diameters on, only connecting flanges are used that comply with the internationally standardized SAE system. Apart from the good sealing properties, it is advantageous that they can be installed using small, handy tools instead of wrenches of arm’s length.

Even first-class components and factory-tested assemblies may fail as a result of improper installation. With regard to safety, cleanliness and environmental protection, the installation of pipes in hydraulic systems is not an unimportant task. This work should be carried out exclusively by qualified companies that are familiar with hydraulics.

- Measuring the lines and the determination of valves and fittings,
- the procurement of installation material,
- the installation of pipes,
- flushing of the pipework and
- testing

should be carried out under the responsibility of *ONE* company specialized in this kind of work!

Planning the piping system theoretically on paper is very complicated. The material required and the line routing can in most of the cases only be worked out and measured on site. It is therefore useful to select a local company near the location of the machine that has the relevant equipment and stock of assembly parts at hand.

An important point is cleanliness of the installation prior to commissioning. Power pack, cylinder and drives are already flushed in the factory. They should only be connected to the mains, if the latter is also clean. This falls under the responsibility of the company that installs the pipes. It must prove the required cleanliness class and document it before the hydraulic components are connected to the mains. This prevents disputes in the case of failures.

BOSCH REXROTH can, of course, carry out the complete pipework. We would be pleased to work out an offer on request.

ELECTRICS

Modern hydraulic systems are controlled, monitored and supplied with power by electric and electronic means. As a rule, electrohydraulic components are grouped in the power pack. Which components are used and which functions do they assume?

Simple three-phase current electric motors are sufficient for driving the pumps and the oil cooler ventilator. Hydraulic pumps need no speed control; deviations in the revving speed result in flow deviations that can hardly be perceived. With level luffing cranes, the pump drive motors start up when the crane's master switch is operated, and they run continuously.

A special point is the use in cold regions. Here, we recommend that at extreme temperatures below freezing the pump motors and the oil heaters continue to run also when the crane is switched off. By analogy, for hot regions, it is advisable to let the oil cooler also run when the crane is switched off.

As soon as the operator actuates the control lever, a signal for boom lowering or boom hoisting is fed to the terminal box of the hydraulic power pack, from where it is passed on to a hydraulic valve with two proportional solenoids. The valve is either provided with integral electronics or is controlled via an electronic card matched to the valve, which assumes the task of converting the signal from the control lever into a current required for actuating the valve.
Depending on which solenoid is energized, the hydraulic system changes over to boom hoisting or boom lowering. The control lever generates a signal that is proportional to the speed and whose amount determines the speed.

Fig. 29: Proportional solenoid valve with integrated control electronics

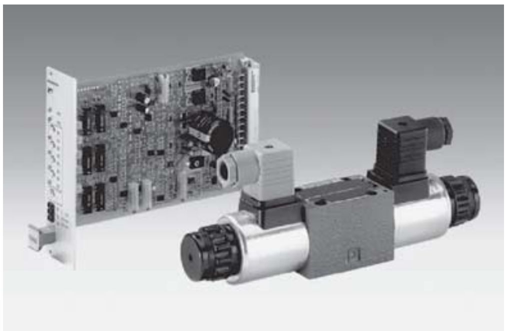


Fig. 30: Proportional solenoid with separate electronic card

Apart from this, monitoring and service functions are required that relate to, for example, for oil level, temperature and pressure.

Safety equipment for the crane
The boom adjustment feature is to decelerate automatically shortly before the minimum or maximum outreach is reached and then switch off. Moreover, it must be avoided that the crane is subjected to excessive loads. The moment of the suspended load and outreach must in no case be exceeded in order to prevent the crane from toppling over.

For the luffing drive control, this means that when the shut-off feature or the load moment limiter respond, the corresponding control signal is interrupted between the control lever and the hydraulic power pack.

Please note:
We assume that existing switches and safety equipment of the crane will also be used in the future and are therefore not taken into account here. We also assume that command signals fed to the power pack are monitored by the crane's electrical system and interrupted in the event of a failure!

ELECTRICS

Interfaces and wiring
Generally, the terminal box on the hydraulic power unit forms the interface with the electrical system. BOSCH REXROTH wires all the electrical components in the power unit to this terminal box. An exception to this is power connections, that is, the wiring of electric motors. To prevent electromagnetic interference, power cables should be connected directly to the terminal boxes of the motors, but not to the terminal box of the power pack. BOSCH REXROTH's scope of supply always includes a terminal diagram.

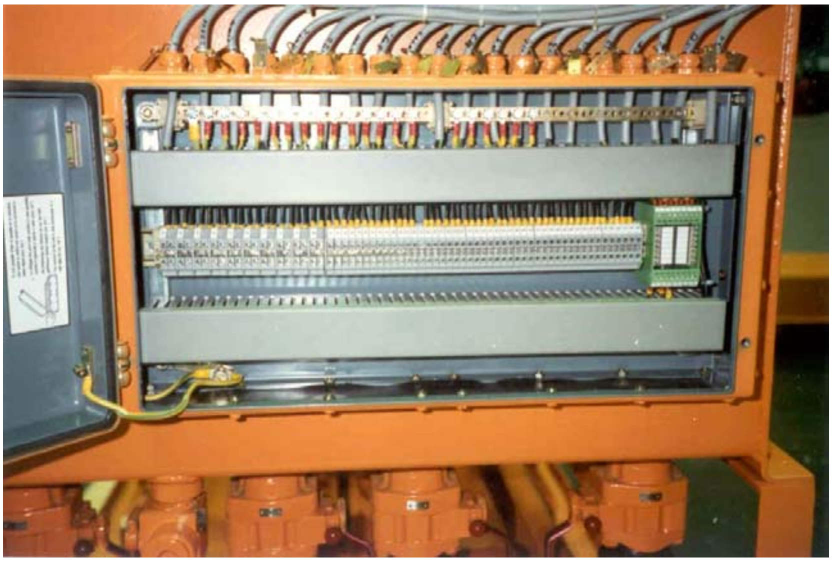


Fig. 31: Terminal box interface on the hydraulic power pack

Conventional solution
So much for the standard scope of supply. Here, it is assumed that the crane manufacturer or the service department of the operator assumes responsibility for the electrical connections of the hydraulic system to the electrical system of the crane and also procures and installs the required hardware. As a rule, any existing central PLC in the crane can be easily extended. In this case, it makes sense to implement the new hydraulic equipment in the existing PLC. The defined interface is then the terminal box on the power unit.

Decentralized intelligence
If no PLC is available or if the power pack with the luffing and slewing drives is to be operated independently of the central crane control, a decentralized control should be considered. For this, BOSCH REXROTH as a system supplier can offer a tailored solution. This variant is interesting for old machines.

Here, the processes taking place in the power unit are processed by a local, autarkic PLC. This relieves the central crane control, which merely sends the command signals. The crane control only triggers the required drive functions and the signals are processed in the control provided by BOSCH REXROTH. This control accommodates all the electrical components required for controlling and monitoring the hydraulic system.

On request, we can also provide the operating elements for manual operation of the drive for the purpose of servicing. Of course, the arrangement in the control cabinet only makes sense, when the operator can observe the drive. If the control cabinet is located too far away from the drive, a loosely supplied operating panel can be included in the scope of supply for mounting at a location that allows observing of the cylinder.

ELECTRICS

Modern field bus systems
Bus systems significantly reduce the cabling effort. If you wish to modernize not only the hydraulic, but also the electrical system, we recommend the selection of a bus system.

In practice, BOSCH REXROTH then connects the electrohydraulic components to the terminal box as with the "conventional solution". However, in this case, a bus adapter - an "intelligent terminal" - is provided as interface with the field bus. BOSCH REXROTH supports all commercial bus systems. If several electrical and electronic assemblies are installed, for example in the control cabinet described before, these assemblies can also communicate with each other via the field bus.
With the conventional solution, the field bus interface is realized with the so-called "intelligent terminal" mentioned before. With the solution of "decentralized intelligence", the field bus node is integrated in the local PLC of the control cabinet.

With new designs or in the case of a modernization of the electrical control, a wide variety of variants are possible. For this reason, we restrict this point in the questionnaire to the indication of the supply voltage for the pump drive motors.

Please contact our specialists, we are pleased to advise you.

PREPARATIONS FOR THE CONVERSION

The machine to be converted should be available as long as possible in the old condition and the time for conversion should be kept short. These are natural requirements of the operator. Forward-looking planning reduces the required time to a minimum.

- Free access for installation and removal must be ensured; the site should be clean and properly lighted.
- The old parts should be removed as late as possible. Disconnected cables and lines must be clearly marked.
- An auxiliary crane is required for the installation of the cylinder, the slewing drive and the power pack.
- The hydraulic power pack can already be installed, the hydraulics connected and the electrical system wired when the old technology is still in service. Even the time-consuming installation of pipework and flushing can already be completed.
  Putting the crane out of service is then only required for the replacement of the actual drives, their connection and for functional tests.

Fig. 32: A hydraulic cylinder always fits in the installation space of a spindle drive!

COMMISSIONING

Initial commissioning of the hydraulic scope of supply should be carried out by a hydraulics specialist.
Also for reasons of warranty, we urgently recommend that BOSCH REXROTH be put in charge of this task.
Faults made during commissioning do not only result in malfunction, but also shorten the service life.

An important point here is the determination of interfaces, for example with the electrical system and piping, that is, services that are not necessarily included in BOSCH REXROTH's scope of supply and services.

MAINTENANCE

A decisive advantage of hydrostatic drives is the low maintenance required, which is mainly limited to the change of filter elements and oil servicing. These points must, however, be strictly observed. Negligence has to be paid for in the form of susceptibility to failures and shortened service life.

Generally, we recommend that the machine be harmonically integrated in the maintenance logistics. For example, the use of hydraulic oils and lubricants, which are filled in your other systems, should be verified. It should be avoided that special oils have to be ordered for modernized machines.

The expected maintenance work is as follows:

- Filter elements have to be changed as indicated, but at least once per year.
- After the first 100 operating hours, pipe fittings must be re-tightened at operating temperature.
- The hydraulic oil is to be changed after the first 2000 operating hours.
- After every further 2000 operating hours, an oil sample is to be sent to any oil manufacturer, who analyzes it for usability. The oil can, of course, also simply be changed.

SPARE PARTS

Hydraulic components are long-life machinery parts. Modern materials and production techniques allow a technically optimized and cost-effective manufacture of individual components. However, the precise matching of the individual parts of components to each other does not allow "optimizations on the workbench"; also the replacement of individual parts can only be recommended to a restricted extent for reasons of stocking and labor cost. Repairs should only be carried out in a qualified workshop. We generally recommend the replacement of complete components.

In particular, we would like to underline safety-relevant parts such as check valves, load lowering valves and type-tested pressure relief valves - in short, all parts, the failure of which represents a risk to life and equipment and where the machine operator can no longer intervene.
For safety reasons, we must reject the replacement of individual parts here.

The scope of supply of the system should include a package with the most important spare parts.
We recommend that it include a sufficient number of filter elements, also for commissioning, as well as an assortment of electrohydraulic components. Electronic amplifier cards are often damaged during commissioning due to incorrect wiring. With the corresponding spare parts at hand, annoying delays can be avoided.